Wisconsin Highway Research Program

WORK PLAN FOR DEVELOPMENT OF A BRIDGE CONSTRUCTION LIVE LOAD ANALYSIS GUIDE

Wisconsin Highway Research Program

COLLINS ENGINEERS, INC.

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WORK PLAN

Research Objective

The objective of this research is to develop a guide for the analysis of construction loads with and without traffic live loads on permanent bridge structures, including construction of new bridges and rehabilitation of existing bridges. The research will also develop specification language indicating the responsibilities of all parties involved to address the loads and ensure that the structure is not overstressed.

Task 1 – Literature Review

A literature review will be conducted to obtain current information concerning the effects of construction loads on structures and the status of any ongoing research projects. The most relevant studies to date appear to be those related to lateral live load distributions. The literature review will include various sources including university library systems, FHWA, TRB, and others. The Linda Hall Library in Kansas City Missouri, home to the ASCE collections, will be included as well. The literature research will also include international resources obtained through Collins offices in Europe. The Department of Transports in the European Union have already prepared documents concerning construction loadings and structure stability. For example, the United Kingdom's BS 5400 outlines information on construction loadings on bridges.

The literature review will include assembling data on equipment loads, load distributions, and impact effects of equipment obtained from equipment manufacturers. Data will be developed for heavy haul/off road trucks, track mount, truck mount and rough terrain cranes, wheeled and tracked loaders, hydraulic excavators, and similar equipment. A summary report of typical load configurations will be developed.

Studies in the distribution of vehicle wheel loads to bridge members have been conducted for many years. This research has increased due to the development and implementation of the AASHTO LRFD Bridge Design Specifications. Though construction loads vary from AASHTO wheel loads, this existing research will be reviewed for its applicability and as guidance for subsequent analytical studies of construction loads.

Task 2 – Present Practices Survey

In order to assist in determining existing practices as they relate to construction loads, both State DOT's and contractors who typically work in Wisconsin will be surveyed for their practices. The DOT survey will solicit information as to any existing loading, analysis, and specification provisions currently in use or under

development. This survey will be sent to all state DOT's. Referenced procedures and information will be requested and reviewed with the survey results. A survey will also be developed and sent to contractors to obtain information on the types of equipment typically used. This information can shed light on the more commonly encountered loads and potentially may establish maximum equipment loads to be encountered on job sites.

Both surveys will be developed by Collins and submitted to WisDOT and WHRP prior to distribution. The surveys will be sent out under WisDOT's letterhead. A higher response rate will be achieved with this approach.

The survey data will be summarized and reviewed by the Investigation Team. The responding DOT's will be provided with a copy of this summary. Collins will meet with a group of Wisconsin bridge contractors early in the study to solicit their input to do the study.

Task 3 – Load Model Studies

Determination of applied equipment loads is not normally difficult, and is based upon equipment supplier data, and in the case of cranes, from computer load analysis for track or outrigger loads. The distribution of these loads to bridge members is not clear. To better understand proper load distributions, 3D computer models of steel girder and concrete girder bridges will be created. These models will be loaded with loads representing "concentrated" loads such as crane outrigger loads, as well as uniform and triangular loads representing track loads. Load positions will be varied along with deck and girder stiffness. From this work, live load distribution factors will be recommended for use in load analysis.

While studies of load distribution for AASHTO wheel loads are available and well understood, construction equipment loads not only differ in magnitude from standard AASHTO loadings, but the loaded area varies significantly from the standard wheel loadings and even amongst different pieces of construction equipment. It is a common construction practice to utilize timber mats, large steel plates and gravel pads to broaden the distribution of concentrated loads on bridge structures in order to keep actually stresses to within "reasonable" limits to avoid permanent damage to the bridge structure. The load distribution study will investigate how effective these techniques are in achieving the load distribution to limit overstresses.

Finite element computer models will be constructed utilizing SAP 2000 software (11th edition) or STAAD to model the loadings and evaluate distributions. A combination of beam and plate elements will be used to model the structures and the load distribution mats. The models will account for deck stiffness and diaphragm contributions in load distribution. Girder and slab bridges will be modeled since these structures represent the most common bridge types. The results of the finite element analysis studies will be used to develop load distribution factors, anticipated to be shown in a chart type format, for various load patterns and bridge geometries.

Task 4 – Design Guide/Handbook

The deliverable for the project is the preparation of a design guide/handbook for analysis of construction loads along with specifications language as to how (and by whom) such analysis is to be undertaken for WisDOT construction projects. Most evaluations of construction loadings utilize LFD or allowable stress methodologies. This seems reasonable for construction conditions, but the guide will address permissible analysis approaches and stress limits. The guide will also require a standard approach to conducting the analysis to include:

- Review of existing bridge drawings
- Review of existing bridge conditions
- Development of construction procedures
- Development of equipment to be used, loads, load placement and controls
- Recommended load distribution factors determined in Task 3.
- Structure analysis
- Connection analysis
- Deck analysis

In addition to equipment loads, materials stockpiles or debris accumulation will be addressed. Typical unit weights for materials will be included as an appendix to the guide. Construction loads may create critical stress conditions that differ from normal bridge load effects. For example, concentrated loads may induce stresses which exceed girder shear capacities near girder ends or cause deck failure due to punching.

In preparing the design handbook, background information on developing equipment loads will be included. For instance, crane loads vary with crane configuration, counterweights, lifted load and radius, tracks may be extended, etc. In addition, track and outrigger loads can vary for ground or structure support conditions. Loads in repositioning equipment may be quite different than operating loads. Other considerations include impact effects both of equipment and related operations such as concrete breaking and pile driving.

Guidance on ways to control or minimize loads/load effects will be included. This includes controlled travel lanes to maximize load distribution, assembling crane counterweights after repositioning of cranes, load transfer grillages and mats, and other techniques. The handbook will include design examples and references for equipment data. Should some equipment be found to be quite commonly used, related equipment data sheets could be included in an Appendix.

Collins will provide recommended special provisions and specifications language that can be used by WisDOT to ensure that bridge construction loads are addressed in a thorough and consistent manner. Final requirements will be dependent upon WisDOT's decisions and may vary with bridge project type and complexity.

Monthly written progress reports will be provided. Collins will attend meetings as may be required.

i. WisDOT Input

The analysis of bridge structures for construction loads has traditionally involved a number of subjective decisions, commonly made by the contractor's engineer or consultant and reviewed by the DOT or their representative.

Issues that may require guidance from WisDOT, and for which Collins will provide recommendations, include the following:

- Once the loads and load analysis is completed, what allowable stresses/load-resistance factors are acceptable for the structural members. Must members be assessed per AASHTO Design Standards or can construction loads be treated as permit loads? This may include the frequency of load applications.
- The existing bridge may be deteriorated and this must be part of the analysis. Should accurate measurements be taken to determine an accurate assessment of the stresses to the deteriorated structure or can a "percent" deterioration be used? What is the basis for establishing the "percent" deterioration?
- Who performs the construction load analysis? The contractor's engineer/consultant commonly does this task. What qualifications does WisDOT want for the engineers and the firms performing this analysis?
- Submittal and review process. Does WisDOT want to review and approve/accept the analysis or is the document only available for review if there are problems encountered during construction?

Communication with WisDOT will be continuous as this project is completed, the items noted above will require particularly close discussions as they are largely issues of policy as opposed to engineering calculations.

B. Anticipated Research Results and Implementation Plan

i. Product Expected from Research

The stated objective of this research project is to develop a guide for structural engineers who work with the construction for the analysis of construction loadings associated with the rehabilitation of existing bridges and the construction of new bridges. It is expected that this document will serve as a guide, rather than a prescriptive manual, that identifies the breadth of loadings to be considered when evaluating construction stresses in new and existing structures.

ii. Product Expected from Research

The guide will be intended for use by Wisconsin and local Departments of Transportation, consulting engineers employed by contractors engaged in construction of bridge structures, resident and construction engineers overseeing the work of contractors and peer review consultants engaged in the review of erection and staging plans.

TIME REQUIREMENTS

The timeline for research activities is detailed below.

	Fiscal 2010												Fiscal 2011		
Activity/Task	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Task 1 – Literature Review															
Task 2 – Present Practices Survey															
Task 3 – Load Model Studies															
Task 4 – Design Guide/ Handbook															
TOC Review															
Final Submittal & Presentation															

Staff commitment for the project by task is shown in the Summary of Hours shown on the table below:

Summary of Hours

INDIVIDUALS	TASKS				TOTAL HOURS
	1	2	3	4	
Principal Investigator Michael Garlich	24	8	16	24	72
Assisting Technical Staff Engineer 3 Paul Wirth	24	8	40	40	112
Assisting Technical Staff Engineer 2 Michael Haas	24	40	40	40	144
Office Staff	8	40	8	40	96
TOTALS	80	96	104	144	424